

decomposable metal compounds into a reaction vessel through a nozzle together with a carrier gas under the conditions  $V/S > 600$ , where  $V$  is the flow rate of the carrier gas per unit time in liters/min, and  $S$  is the cross-sectional area of the nozzle opening part in  $\text{cm}^2$  and producing the metal powder by heating the raw material powder at a temperature which is higher than the decomposition temperature of the raw material powder and not lower than  $(T_m - 200)^\circ\text{C}$  where  $T_m^\circ\text{C}$  is the melting point of the metal, in a state where the raw material powder is dispersed in the gas phase at a concentration of 10 g/liter or less.

In the present invention, it is very important that the solid raw material powder be ejected into the reaction vessel through a nozzle together with a carrier gas at a specified linear velocity and that the powder be subjected to heat treatment at a low concentration and in a highly dispersed state in the gas phase so that the raw material particles and product particles do not collide with each other.

In order to obtain a high degree of dispersion of the solid raw material powder in the gas phase, the powder is ejected into the reaction vessel at a high speed through a nozzle under the conditions that  $V/S > 600$ , where  $V$  is the flow rate of the carrier gas per unit time in liters per minute and  $S$  is the cross-sectional area of the nozzle area opening part in square centimeters. Under these conditions, the raw material powder is dispersed extremely well in the gas phase without any re-aggregation as a result of the rapid expansion of the gas inside the reaction vessel. This enables a fine metal powder having an extremely narrow particle size distribution to be produced.

A conductive metal powder is used to make conducted paste that form electronic circuits. It is preferred that these powders contain as few impurities as possible, the fine powders have a main particle size ranging from 0.1 microns to approximately 10 microns, have a uniform particle size and particle shape and that the particles be monodispersed

particles with no aggregation. Its also necessary that the dispersability of the powder into the paste be good and that the crystallinity of the powder be high so there is no non-uniform sintering. The present invention accomplishes these goals.

The Akimoto et al patent application publication discloses a method for preparing a highly crystallized metal powder comprising the steps of supplying at least one heat-decomposable metal compound powder into a reaction vessel using a carrier gas and forming a metal powder by heating the metal compound powder in a state in which the metal compound powder is dispersed in a gas phase at a concentration of no more than 10 g/liter, at a temperature that is over the decomposition temperature of the metal compound powder and at least  $(T_m - 200)^{\circ}\text{C}$ , where the melting point of the metal contained in the metal compound powder is  $T_m^{\circ}\text{C}$ .

As admitted by the Examiner, this reference does not disclose  $V/S > 600$ , which is a critical feature of the present invention. The Examiner states that performing the prior art process at the conditions specified in the instant claims would fall within the purview of the Akimoto process. Applicants respectfully traverse this position because, as stated above, the ratio  $V/S > 600$  is a critical part of the present invention and arguments in support of this proposition will be made below.

The Gonzalez et al reference discloses a chloride process for producing titanium dioxide by adding an inert gas in a vapor phase reaction of titanium tetrachloride and an oxygen-containing gas. This reference has been cited by the Examiner as disclosing that, at the time of the invention disclosed there, it was known that it was preferable to employ a high ratio of carrier gas to a nozzle size with a minimum cross-sectional area in processes of making powders by the reaction of raw material powders and, as such, it would be obvious to one of ordinary skill in the art to employ the high ratio required by the present claims. As implicitly admitted

by the Examiner, this reference does not disclose a specified  $D/S > 600$  requirement for the ratio of flow rate of carrier gas to cross-sectional area of nozzle.

Another difference between the present invention, the Akimoto et al patent application publication and the Gonzalez et al reference is that the Gonzalez et al reference discloses a vapor phase reaction to obtain the product titanium dioxide while the Akimoto et al patent application publication and the present invention require that the reactants be provided in the form of on a powder. Although solid particles of titanium dioxide form during the reaction in Gonzalez et al, the reactant streams are vapor streams and any disclosure in this reference with respect to the high ratio of carrier gas to nozzle size for the vapor phase reaction disclosed there cannot be extended to the solid phase reaction required by the present claims.

The claimed  $V/S$  ratio was arrived at in order to assure that the raw material powder be mixed and dispersed in the carrier gas uniformly without any re-aggregation of the raw material powder. The vapor phase reactants of Gonzalez et al does not present such a concern and, as such, it is respectfully submitted that this reference adds nothing to the primary Akimoto et al patent application publication.

U.S. Patent Application Serial No. 10/630 394 has claims directed to a method for manufacturing a highly-crystallized oxide powder. Like the previously discussed references, the claims of this patent application has no disclosure with respect to ejecting a raw material powder into a reaction vessel through a nozzle together with a carrier gas under the condition that  $V/S > 600$ , where  $V$  is the flow rate of the carrier gas per unit time in liters per minute and  $S$  is the cross-sectional area of the nozzle opening part in square centimeters. Since this ratio is a critical part of the present invention, it is respectfully submitted that the current represented claims are unobvious over the claims of application Serial No. 10/630 394.

In response to applicants arguments that there is objective evidence in the present application which is more than sufficient to rebut any showing of prima facie obviousness under 35 USC 103(a), the Examiner states that nothing in the disclosure regarding Example 1 and comparative Example 1 can be said to show that a V/S minimum value of 600 is critical to achieving any particular effects. However, invention Example 2 utilizes a V/S of 670. It is believed that a comparison of invention Example 2 with comparative to Example 1, which has a V/S of 400, establishes the criticality of the presently claimed ratio.

In order to expedite the prosecution of the present application, applicants are enclosing herewith a Declaration Under 37 CFR 1.132 which further establishes the criticality of the presently claimed V/S ratio. In Example A, as shown in Table A in the enclosed Declaration, the V/S ratio was 630 while comparative Example A had a V/S ratio of 540, comparative Example B had a V/S ratio of 480 and comparative Example 1 had a V/S ratio of 400. As can be seen from the results in Table A in the enclosed Declaration, the powders produced according to the present invention had a much smaller particle size dispersion. This establishes the criticality of the claimed V/S ratio and affirms the unobviousness of the present claimed invention over the prior art cited by the Examiner.

The Examiner seems to understand that the D99.9/D50 ratio in this invention corresponds to the maximum/average particle size ratio and compares the average/maximum particle size ratios shown in Akimoto's Examples 4 and 9 with the D99.9/D50 ratios shown in the invention examples (item a on page 5 of the office action). However, applicants respectfully disagree. Although the Examiner seems to believe that the average particle size and the maximum size measured by SEM in Akimoto's examples are indicators to show the particle size distribution and the ratio thereof corresponds to the D99.9/D50 ratio, mere measurements of the average and maximum

particle sizes are not sufficient to examine the particle size dispersion.

Recognizing the method disclosed in Akimoto, the inventors made further detailed experimental investigations. As a result they discovered that the D99.9/D50 ratio should be used as an index to determine the degree of particle size dispersion of the intended metal powder and found that the D99.9/D50 ratio is closely related to the V/S ratio. Through the present inventors' experiments, the claimed V/S was determined in order to obtain metal powders having a narrow particle size dispersion, i.e., a small D99.9/D50 ratio, in a more stable manner and with good reproducibility. Therefore, ensuring the claimed high V/S ratio is essential to this invention.

Measurement of particle size distribution by a laser diffraction particle size analyzer is per se known from many patents and the dispersion degree is expressed, for example by D50, D60, etc. D50 and D99.9 in this invention are used in the usual technical sense. For example, the 99.9% diameter (D99.9) was 1.1  $\mu\text{m}$  which means that 99.9% of particles constituting the powder had a particle size of no more than 1.1  $\mu\text{m}$  (paragraph 0032 of this application). Similarly, D50 of 0.51  $\mu\text{m}$  in paragraph 0032 means that 50% of particles constituting the powder had a particle size of no more than 0.51  $\mu\text{m}$ . Akimoto is silent about the D99.9/D50 ratio and does not pay any attention to the V/S value. Akimoto does not give any information about the V/S or D99.9/D50 ratio, let alone the specified V/S giving a small D99.9/D50 ratio.

The Examiner states that the small max/average particle size ratios in Akimoto's Examples 4 and 9 are narrow particle size distributions. If the Examiner is correct, the particle size distribution of Akimoto's Examples 1 to 3 have to be considered broad because of the large maximum/average particle size ratios, i.e.,  $2.0/0.5 = 4.0$  for Example 1;  $2.0/0.6 = 3.3$  for Example 2;  $1.8/0.5 = 3.6$  for Example 3 (Akimoto's Table 1) as compared with Akimoto's Examples 4 and 9 and it is felt

that Akimoto teaches that coarser raw material compound powder, a high supply rate of the raw material powder, and a high concentration of raw material powder dispersed in the gas phase inside the reaction tube result in powder products having a narrow large maximum/average particle size dispersion, because Akimoto's Example 4 uses coarser raw material compound powder having an average size of 2.5  $\mu\text{m}$  and a maximum size of 6.0  $\mu\text{m}$  at a very high supply rate of 62.5 kg/hr and a high concentration of raw material powder of 5.0 g/liter in the gas phase. Since Akimoto does not mention other parameters, the others are considered unchanged.

However, according to the present invention, a higher concentration of raw material powder dispersed in the gas phase inside the reaction tube (5.0 g/liter) in Example 5 makes the particle size dispersion slightly broader as compared with the other Examples and this result is opposed to Akimoto's result expressed by the average particle size/maximum particle size. In view of this, applicants respectfully disagree with the Examiner's assertion that the average particle size/maximum size ratio in Akimoto teaches applicants' narrow particle size dispersion expressed by D99.9/D50 and the V/S of this invention would be inherent in the disclosure of Akimoto's method.

As discussed above and in the last Response, the raw material powder is injected into a reaction vessel through the nozzle together with the carrier gas at a high linear velocity of  $V/S > 600$ , resulting a fine metal powder with an extremely narrow particle size distribution at a high stability, as demonstrated by the invention examples. Akimoto is entirely silent about the recognition of V/S, let alone the specified V/S of higher than 600.

Reconsideration of the present application and the  
passage of the issue is respectfully solicited.

Respectfully submitted,

  
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